(12) UK Patent Application (19) GB (11) 2 185 116 (13) A

(43) Application published 8 Jul 1987

(21) Application No 8600282

(22) Date of filing 7 Jan 1986

(51) INT CL⁴
G01M 1/10

(52) Domestic classification (Edition I)
G1X 24
U1S 1987 2036 2172 G1X

(56) Documents cited
None

(58) Field of search
G1X
Selected US specifications from IPC sub-class G01M

(71) Applicant
Rolls-Royce Limited,

(Incorporated in United Kingdom),

65 Buckingham Gate, London SW1E 6AT

(72) Inventors
John Henry Hobson,
John Boyes Hamlin

(74) Agent and/or Address for Service
M. A. Gunn, Patents Department, Rolls-Royce Limited,
P. O. Box 31, Moor Lane, Derby DE2 8BJ

(54) Moment weighing apparatus and method of moment weighing a member

(57) Blades (10) for use in gas turbine engines are individually moment weighed in each of three attitudes which represent the directions in which operational forces act on the blades, whilst at the same time, the moment weighing device applies a load to a blade being moment weighed, which load is a significant % of the centrifugal force exerted on the blade during the said operation.

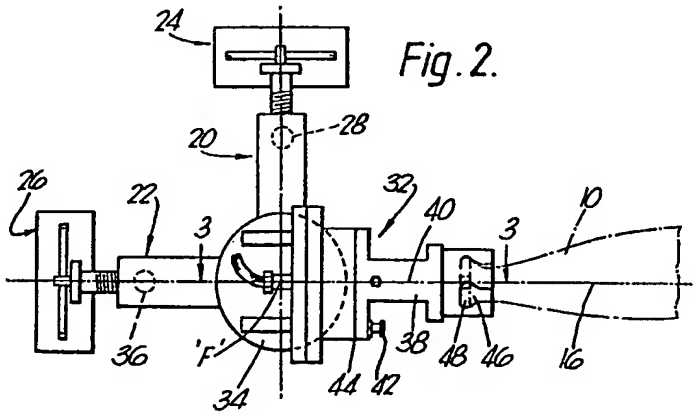

Fig. 2.

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The drawing(s) originally filed was (were) informal and the print here reproduced is taken from a later filed formal copy.

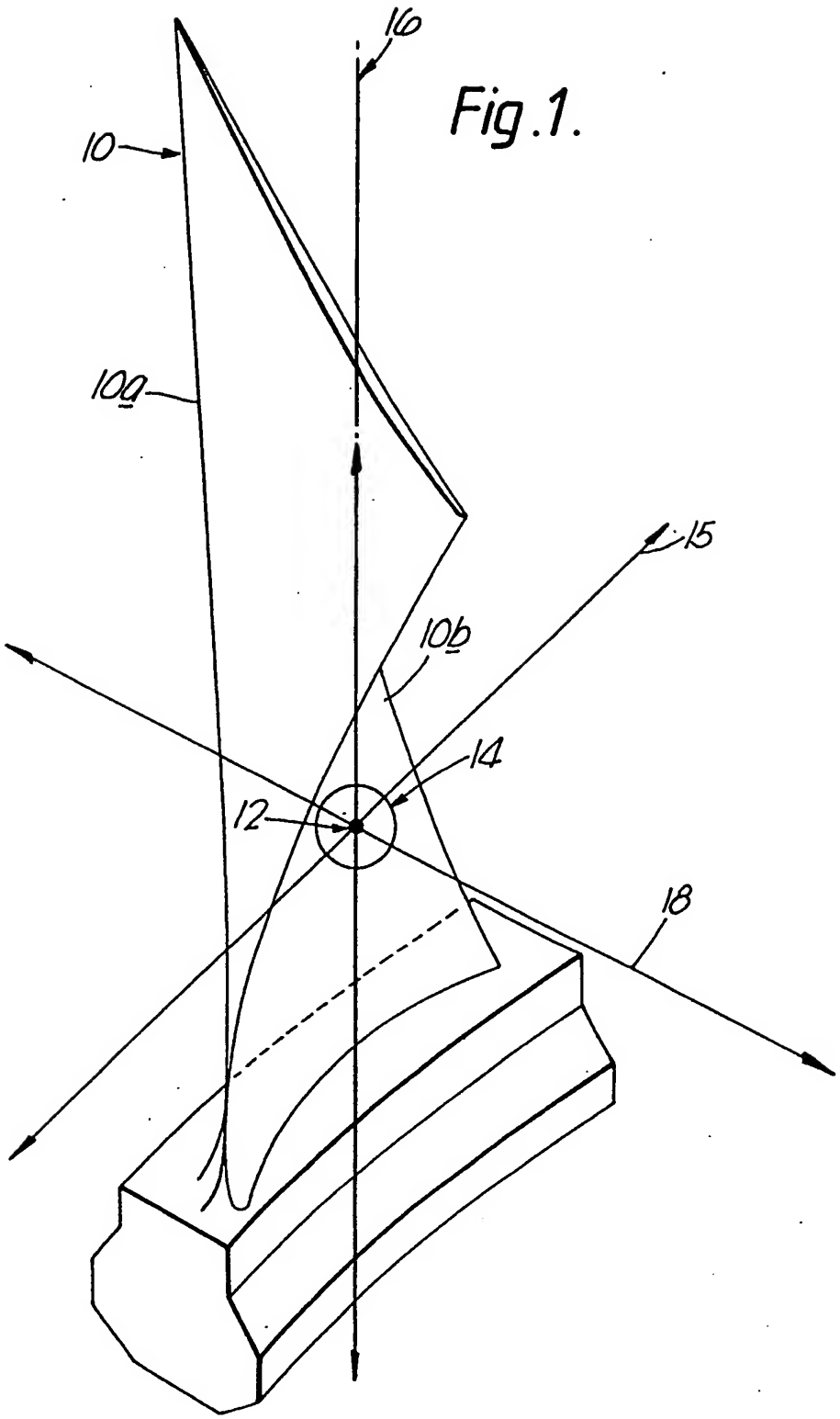


Fig.1.

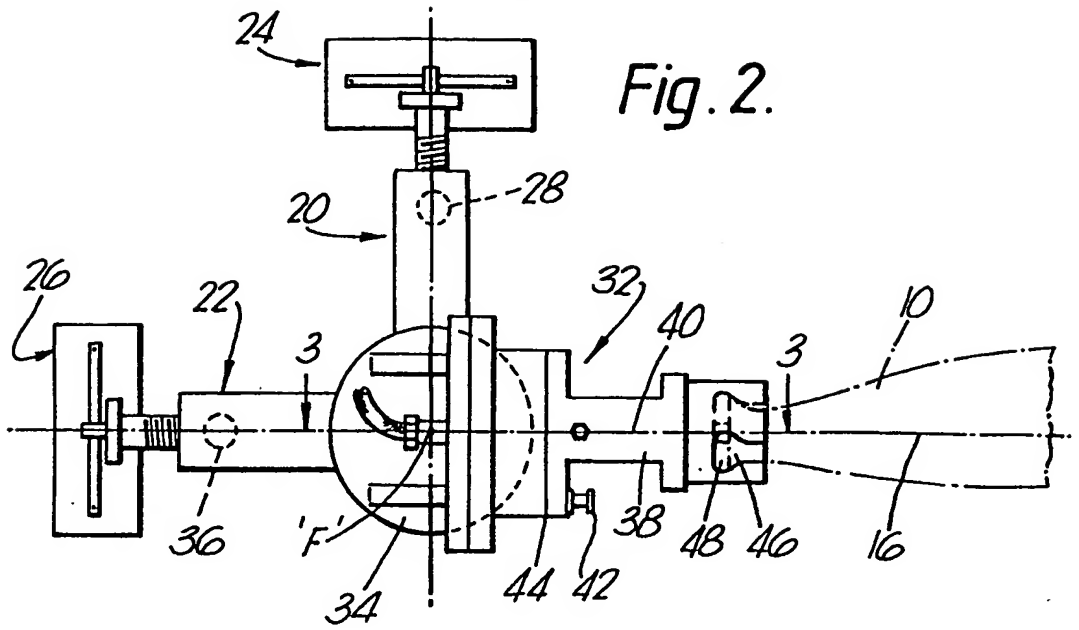
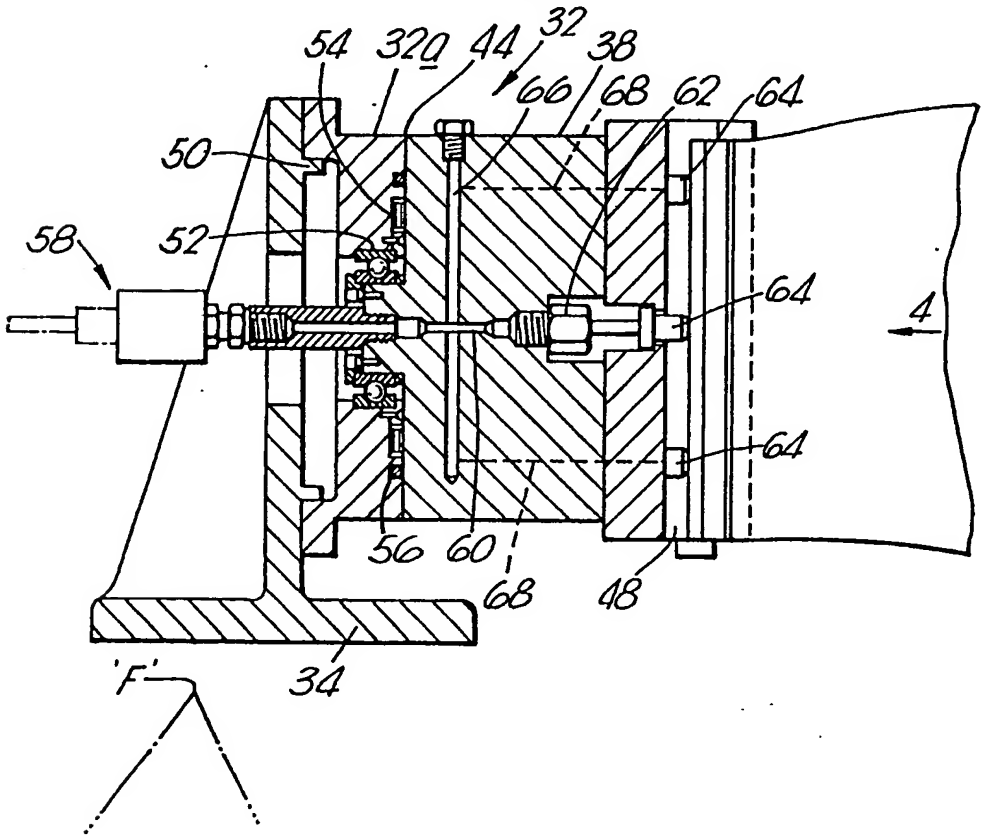

24
20
28
26
22
3
32
40
3
10
36
'F'
34
44
42
38
48
46
16

Fig. 2.

Fig. 3.


54
320
44
32
38
66
68
62
64
50
52
58
64
4
64
56
60
68
48
34
'F'

SPECIFICATION

Moment weighing apparatus and method of moment weighing a member

This invention relates to apparatus for moment weighing members which in operation orbit about a centre of arc.

The invention further relates to a method of moment weighing such said members.

Apparatus is known, which enable the moment weighing of solid members, e.g. aerofoil blades of the kind used in ducted fan gas turbine engines and turbo jet engines.

Apparatus is also known, which enables the moment weighing of members e.g. solid aerofoil blades, the moment centre of which causes tilting of the apparatus both downwards and sideways i.e. in a plane which lies at some compound angle to a plane which passes through the apparatus fulcrum and contains some datum line in the aerofoil blades.

Such is the dimensional accuracy of the solid aerofoil blades, and the consistancy of metal density, that it has not been found necessary to provide anything but ordinary core in positioning each blade in the apparatus for the purpose of moment weighing, in order to obtain very accurate moment weight values. Such consistency has also enabled the employment of simple clamping means by which a blade is held in the said position.

The advent of the hollow aerofoil blade the interior of which contains either a hpney comb core or has the inner surfaces of its flanks joined by local protruberences or channel members, whilst maintaining a high degree of profile dimensional accuracy, has generated problems by way of variable density, both in magnitude and position, in the core structure.

It is necessary to achieve the high degree of accuracy mentioned hereinbefore, i.e. in the order of a 0.01% tolerance band. It has been found that known apparatus is not capable of supporting a hollow blade of the kind hereinbefore described, in a manner which enables the desired, repeatable accuracy to be achieved. In consequence, the present invention seeks *inter alia* to provide an improved moment weighing apparatus.

According to the present invention, a method of statically moment weighing a blade which in operation orbits about the axis of a gas turbine engine, so as to achieve the apparent moment weight of the blade as effected by centrifugal force during said operation comprises the steps of loading the blade *via* its root into a complementary groove in a moment weighing device and applying a load to the underside of the blade root, which load approximates the centrifugal load experienced by the blade during said operation, and maintaining said load during moment weighing.

Preferably the method includes the step of sequentially moment weighing the blade in a number of attitudes and changing said attitudes by indexing that portion of the device which includes the groove about an axis which includes the stacking line of the blade.

The load applying means may comprise hydraulically operated ram means connected to the load transmitting means.

The moment weighing apparatus may include a plurality of balance weight stations so as to enable three dimensional weighing of a said aerofoil blade.

The invention will now be described by way of example and with reference to the accompanying drawings in which:

Figure 1 is a pictorial view of an aerofoil blade of the kind suitable for moment weighing on the apparatus of the present invention.

Figure 2 is a diagrammatic plan part view of apparatus in accordance with the present invention.

Figure 3 is a view on line 3-3 in Figure 2.

In Figure 1, an aerofoil blade 10 has a honeycomb core structure (not shown) enclosed in the sheets 10a, 10b which make up the flanks of the aerofoil blade 10

The aerofoil blade 10 has a centre of gravity in the nominal position indicated by the arrow 12. However, it has been found that the method of manufacture employed, introduces variation in core honeycomb size and metal placement. The actual position of the centre of gravity of a blade 10 may thus be anywhere in an area approximately bounded by the line 14.

As can be seen in Figure 1, the centre of gravity 12 can be displaced in either direction indicated by double head arrow 15, fore or aft of a line 16 which as is known by experts in the field, as the stacking line i.e. a line which is substantially radial to the axis of a disc (not shown) on the periphery of which the blade 10 will be mounted for operation. The line 16 also provides a datum about which the blade aerofoil chord is twisted throughout the length of the blade 10, to achieve for example, the shape depicted.

The centre of gravity 12 may also be displaced to one side of the stacking line 16 in either of the directions indicated by the double headed arrow 18, e.g. a line which is tangential to the orbital path of the blade 10 during operation thereof.

Finally, the centre of gravity 12 can be displaced from nominal, in directions coincident with or in parallel with, the stacking line 16.

In order to counter the three dimensional displacement of the centre of gravity of the blade 10, it is necessary to moment weigh it in three attitudes so as to achieve each of the radial and tangential (with respect to a disc on which the blade 10 will be mounted for operation), moment weights and fore and aft moment weights. This operation is performed on a moment weighing machine as depicted in Figures 2 and 3 of the drawings, to which reference is now made.

In Figure 2, the counter moment arms 20 and 22 of a moment weighing apparatus are interconnected and mounted for pivotal movement about a fulcrum 'F'. The arms 20,22 supports respective weight trays 24, 26 in known manner. Transducers 28,30 are positioned under respective arms 20,22 for contact thereby, and generate signals which result in the display of digits (not shown) representing the moment weight of an object which is being moment weighed.

The apparatus described so far is known and can be obtained from Carl Schenk A.G. D-6100 Darmstadt, W Germany. There is however, an addition in

the form of a novel holding device 32, whereby a blade 10 is held and orientated for the purpose of achieving the three dimensional moment weighing described hereinbefore, to within a repeatable accuracy of 0.01% for each such blade 10.

The device 32 is mounted on the moment weighing apparatus at the junction of arms 20 and 22 *via* a flanged base plate 34. That end portion 38 of the device 32 is indexable relative to the remainder thereof, about an axis 40 which coincides with the stacking line 16, and which passes through the fulcrum 'F'.

An anti-indexing plunger 42 crosses the interface 44 between the relatively rotatable parts of the holding device 32. The plunger may be withdrawn when indexing of the portion 38 is required.

In the present example, the root 46 of the blade 10 is dovetailed in cross sectional shape and fits in a complementary groove 48 in the indexable portion 38. The manner of its retention is best seen in Figure 3, which will now be described.

In Figure 3 the device 32 has a fixed part 32a which is located on the flange of the base plate 34 *via* a spigot 50, and the indexable part 38. The latter is supported from the fixed part 32a *via* a thrust bearing 52. Roller bearings 54 are recessed into the face of the fixed part 32a, and contact the indexable part 38 at the interface 44.

A ring seal 56 seals the interface 44.

A pressurised supply of fluid is connectable to the device 32 *via* connectors 58. The fluid, when required, is passed *via* conduit 60 to rams contained in cylinders 62 of which only one is shown. The rams in turn, transmit the pressure to pads 64 which protrudes through the floor of the groove 48. The rams and cylinders, which are not shown, each receive pressurised fluid *via* branch conduits 66 and 68.

In operation of the apparatus, a blade 10 is loaded by sliding the root 46 thereof into the complementary groove 48 in the device 32.

The end of the root 46 is caused to abut a stop 70 and then pressurised fluid is supplied to the cylinders 62 with the result that the pads 64 are urged against the under-side of the root 46, thus trapping the blade 10 *via* its root flanks, against the corresponding re-entrant side of the groove 48.

The magnitude of the pressure exerted on the root 46 of the blade 10 is approximately that experienced by the and each blade 10 when operating in a gas turbine engine, but in any event, must be a significant percentage thereof.

The pressure is maintained until the blade 10 has been moment weighed in each of the three attitudes which were described hereinbefore. This ensures that the centre of gravity, of the blade is the same distance from the fulcrum 'F' in each attitude, as the distance it will be from the axis of rotation when operating in a gas turbine engine. From this it follows that the device 32 must be proportioned so as to enable achieving of the common position and further, must be manufactured with great accuracy.

The invention has been described as being suitable for moment weighing blades 10 which have dovetail roots. However, the groove 48 may be shaped so as to be complementary to any root form.

On completion of the moment weighing opertion, the observed moment weight for each attitude is marked on the respective blades, which are then stored.

On withdrawal of a complete set of blades from stores for assembly on a pre balanced disc, the blades moment weights are first entered into a computer, which is programmed to sort the moment weights and issue an instruction regarding the best positions in which blades should be placed on a disc rim with respect to each other so as to provide a balanced assembly. The necessity to rotary balance the complete assembly is thus obviated.

CLAIMS

1. A method of statically moment weighing a blade which in operation orbits about the axis of a gas turbine engine, so as to achieve the apparent moment weight of the blade as effected by centrifugal force during said operation, comprising the steps of loading the blade *via* its root into a complementary groove in a moment weighing device and applying a load to the underside of the blade root, which load approximates to the centrifugal load experienced by the blade during said operation, and maintaining said load during moment weighing of the blade.

2. The method of statically moment weighing a blade as claimed in claim 1 including the step of sequentially moment weighing the blade in a number of attitudes and changing each attitude thereof by indexing that portion of the device which includes the groove about an axis which includes the stacking line of the blade.

3. The method of statically moment weighing a blade as claimed in claim 1 or claim 2 including the step of applying a hydraulic load to the underside of the blade root.

4. Moment weighing apparatus suitable for moment weighing an aerofoil blade which in operation orbits about the axis of a gas turbine engine, comprising a device having a re-entrant groove in an end face, which re-entrant groove is complementary kin form to the root portion of a said aerofoil blade and in operation receives the said aerofoil blade *via* its root portion, movable load transmitting means in the body of the device and in communication with the groove so as to enable contact with the underside of a said blade root portion and load applying means for applying a load *via* said load transmitting means to the said underside of a said root portion, which load equals the load exerted on a said blade when the said blade orbits about said axis.

5. Moment weighing apparatus as claimed in claim 4 wherein the load transmitting means comprises a piston, an end of which in operation abuts the underside of a said root portion of a said blade so as to transmit said load.

6. Moment weighing appartus as claimed in claim 4 or claim 5 wherein the load applying means comprises hydraulically operated ram means which are connected to the load transmitting means.

7. Moment weighing apparatus substantially as described in this specification and with reference to the drawings.

Printed for Her Majesty's Stationery Office by
Croydon Printing Company (UK) Ltd, 5/87, D8991685.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY,
from which copies may be obtained.